STEEL
Success Story

STEEL REHEATING FOR FURTHER PROCESSING

Energy Efficient, Low NO_x Burner Retrofit Burns Coke Oven Gas

Benefits

- Reduces energy consumption as much as 60% per ton of steel
- Reduces NO_x and particulate emissions by 60-90% per ton of steel
- Eliminates installation of heat recovery and NO_x removal equipment

Applications

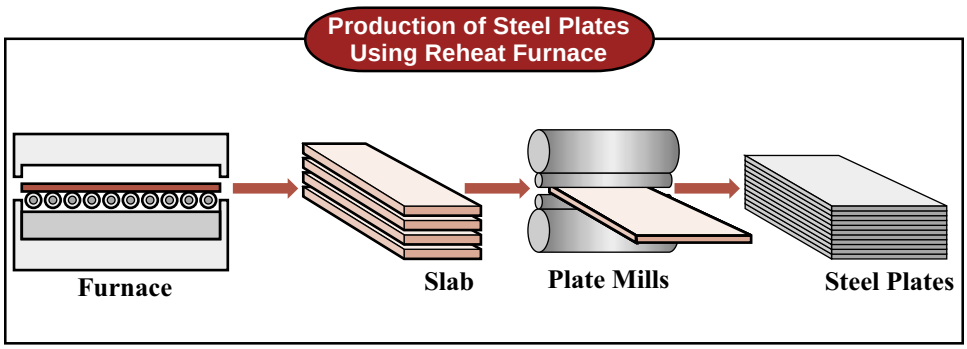
The energy efficient, low NO_x burner retrofit can be used in high temperature industrial applications like steel reheating furnaces where temperature uniformity is critical and extremely low NO_x emissions are desired.

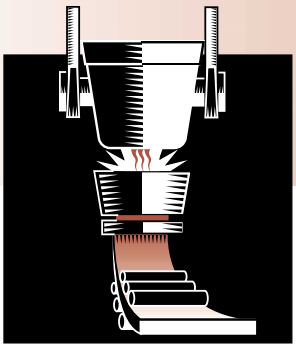
Reheating steel in a furnace before hot rolling it is an energy-intensive process. Large steel slabs are reheated to 1120°C with an internal temperature gradient less than 100°C. Using oxygen-enriched air in conventional burners increases furnace energy efficiency, but also reduces slab heating uniformity and increases NO_x emissions. Praxair, Inc., who develops patented technologies and supplies oxygen and other industrial gases to the steel industry, has developed an innovative burner retrofit for steel reheat furnaces. By injecting oxygen and fuel gas through separate lances before combustion, this retrofit produces more uniform heating and reduces NO_x production.

With support from the U.S. Department of Energy's NICE^3 (National Industrial Competitiveness through Energy, Environment, and Economics) Program and the Indiana Department of Commerce, Bethlehem Steel Corporation's Burns Harbor Division installed Praxair's burner design on an inherently less efficient, small batch reheat furnace at their 160-inch steel plate mill. The retrofit is based on Praxair's patented oxy-fuel burner design that reduces NO_x generation during burner operation and substantially reduces the volume of flue gas. At Burns Harbor, the oxy-fuel burners are fueled with oxygen and coke oven gas, an inexpensive by-product fuel created in the process of reducing coal to coke.

Technology Development

The Burns Harbor project was initiated in October 1997 with baseline tests of the existing furnace before the new burners were installed. In July 1998, the new burners were installed and operating. From July 1999 though January 2000, furnace gases and fuel use were monitored, and heating uniformity was evaluated using an instrumented slab. The final results were sent to the Department of Energy in June 2000.





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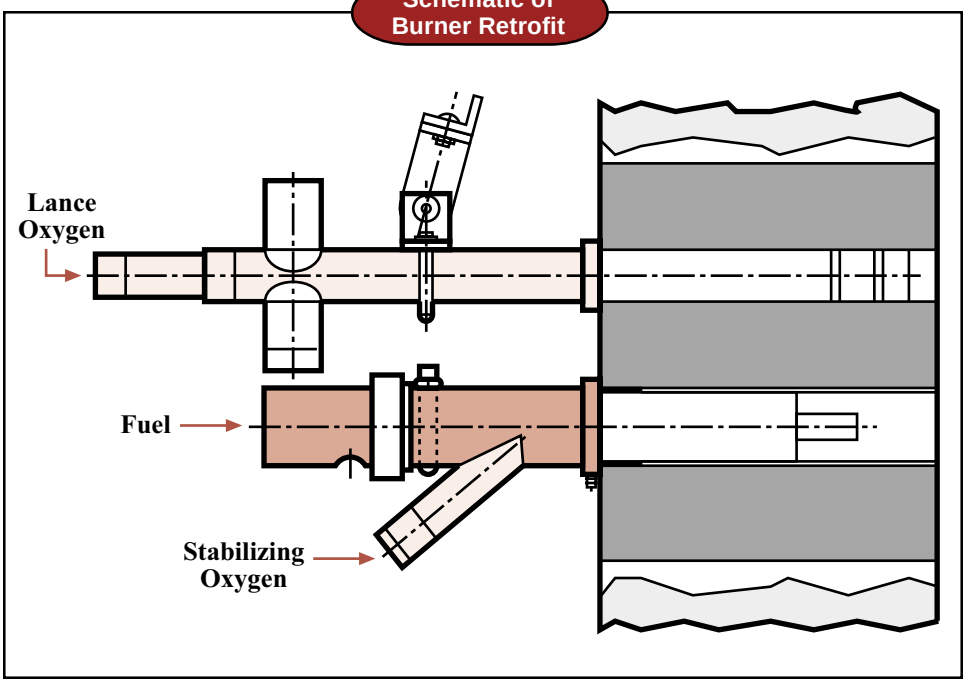
The furnace retrofit replaces the conventional air burners with Praxair's patented oxy-fuel burner design. Four oxy-fuel burners with total firing capacity of 24 million Btu/hr replaced eight conventional burners with total firing capacity of 50 million Btu/hr. As shown in the schematic below, the oxy-fuel burners consist of separate fuel and oxygen lances mounted in refractory tile and attached to the furnace shell. Oxygen is piped from a cryogenic separation plant to each burner's oxygen lance.

The furnace retrofit saves energy because of the dramatic increase in fuel efficiency that occurs when oxygen instead of ambient air is used during combustion of hydrocarbon fuel. Air is composed of approximately 21% oxygen, 78% nitrogen, and 1% various other gases. During air-fuel combustion, the chemically inert nitrogen dilutes the reactive oxygen and carries away some of the energy in the hot combustion exhaust gas. With oxy-fuel burners, nitrogen has been removed from the burner gases, so combustion heat is not wasted on heating inert nitrogen.

Schematic of Burner Retrofit



"The NICE³ project demonstrated solutions to several difficult combustion challenges, achieving stable combustion operation under a wide temperature range, maintaining good operation during batch furnace charging, and generating low NO_x emissions with coke oven gas."

–Michael Riley
Applications Research and Development
Praxair, Inc.

"Significant fuel savings and NO_x reductions were achieved in the production environment with no loss of heating uniformity, quality, or productivity, paving the way for more installations."

—Anthony Martocci
Program Manager of Corporate Energy Affairs
Bethlehem Steel Corp.

OFFICE OF INDUSTRIAL TECHNOLOGIES

ENERGY EFFICIENCY AND RENEWABLE ENERGY
U.S. DEPARTMENT OF ENERGY

STEEL
Success Story

Project Partners
- Praxair, Inc.
  Tarrytown, NY
- Bethlehem Steel Corp.
  Bethlehem, PA
- Bethlehem Steel Corporation
  Burns Harbor Division
  Burns Harbor, IN
- Indiana Department of Commerce
  Energy Policy Division
  Indianapolis, IN

To inhibit NO_x production, the oxy-fuel burner design and flow controls provide for lower flame temperature and close control of excess oxygen during burner operation. Ninety percent of the oxygen needed for complete combustion is injected through the oxygen lance. The remaining ten percent is injected around the fuel lance to provide stable combustion, especially when the furnace is opened to allow steel to be inserted or removed.

Energy Savings and Pollution Prevention

Bethlehem Steel has produced over 100,000 tons of steel with the burners. Compared with furnaces using conventional air burners, Bethlehem Steel's reheat furnace retrofitted with oxy-fuel burners achieves fuel savings of 60%. Over 385 billion Btu of energy have been saved using the oxy-fuel burners through 2000. The associated cumulative reduction in CO_2 emissions is over 23 thousand tons. Cumulative energy savings from oxy-fuel burners at all Bethlehem Steel facilities are projected to grow exponentially by the year 2010 as oxy-fuel burners are installed across the corporation.

Energy Savings
(Billion Btu)

Cumulative through 2000
385

Emissions Reductions
(Tons cumulative through 2000)

Particulates	NO_X	CO_2
30	82	23,000

Potential Economic Benefits

Installing a new furnace or expanding an existing furnace is constrained by the physical space available, emissions regulations, and the large amount of capital required. An existing furnace can be retrofitted with oxy-fuel burners for greater productivity with the same or less flue-gas-handling equipment. Estimated installation cost for the retrofit is $300,000 to $400,000.

After deducting the cost of oxygen and including the cost savings from burning coke oven gas, Burns Harbor Division is realizing savings of $450,000/yr (annualized savings based on fuel costs during the last six months of 2000). Burning coke oven gas results in the need to replace furnace tiles during scheduled maintenance outages and maintaining check valves monthly, but costs are minimal compared with the savings.

OIT
March 2001

Market Information

The commercial demonstration of this technology paves the way for the installation of oxy-fuel burners at other steel mills. Bethlehem Steel Corp. is considering the conversion of additional furnaces at Burns Harbor and other locations to oxy-fuel burners. Widespread use of this technology has the potential to save millions of dollars in energy costs for the U.S. steel industry, thereby increasing its overall competitiveness. Additionally, this technology helps to reduce emissions of undesirable gases and improve the local air quality.

Steel Slab inside the Reheat Furnace

Industry of the Future — Steel

Through OIT's Industries of the Future initiative, the Steel Association, on behalf of the steel industry, has partnered with the U.S. Department of Energy (DOE) to spur technological innovations that will reduce energy consumption, pollution, and production costs. In March 1996, the industry outlined its vision for maintaining and building its competitive position in the world market in the document, ***The Re-emergent Steel Industry: Industry/Government Partnerships for the Future.***

OIT Steel Industry Team Leader: Peter Salmon-Cox (202) 586-2380.

NICE³ – National Industrial Competitiveness through Energy, Environment, and Economics:
An innovative, cost-sharing program to promote energy efficiency, clean production, and economic competitiveness in industry.
This grant program provides funding to state and industry partnerships for projects that demonstrate advances in energy efficiency and clean production technologies. Awardees receive a one-time grant of up to $525,000. Grants fund up to 50% of total project cost for up to 3 years.

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